

# Component skills of reading and their structural relations: evidence from three sub-Saharan African languages with transparent orthographies

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**Background:** We examined the component skills of reading comprehension (i.e., letter sound knowledge, syllable reading fluency, decoding fluency, text or oral reading fluency and listening comprehension) and their structural relations using data from three sub-Saharan African languages with transparent orthographies in a multilingual context.

**Methods:** Data from Kiswahili ( $N = 946$ ), Kikamba ( $N = 444$ ) and Lubukusu ( $N = 499$ ) reading assessments at the end of Grade 2 in Kenya were analysed using path analyses.

**Results:** The magnitudes of the relations were similar across the three languages with some differences amongst the languages. Total effects (regression weights), accounting for direct *and* indirect effects, varied across the component skills: text reading fluency (0.73 to 0.77), decoding fluency (0.49 to 0.82), letter sound knowledge (0.44 to 0.45), syllable reading fluency (−0.12 to 0.16) and listening comprehension (0.08 to 0.23).

**Conclusions:** The results indicate similar reading mechanisms across the three sub-Saharan languages.

**Keywords:** oral reading fluency, text reading fluency, reading comprehension, transparent orthography, Africa

## Highlights

What is already known about this topic

- Letter sound knowledge is important to word reading.
- Word reading, text reading fluency and listening comprehension are important to reading comprehension.

### What this paper adds

- Structural relations amongst component skills
- Estimates of direct and indirect effects for total effects of component skills on reading comprehension
- Generalisability of component skills to transparent orthographies in sub-Saharan contexts

### Implications for theory, policy or practice

- Results show the importance of accounting for indirect effects of component skills for their contributions to reading comprehension.
- Results show pathways of relations.
- Reading comprehension requires building solid foundations in the component skills at both sublexical and lexical levels.

Reading skills are essential in today's information-driven society. Numerous studies in the past four decades have revealed that reading involves highly complex processes, ranging from sublexical to text-level processes. However, most research has been conducted with English-speaking children (Share, 2008) and in developed countries, and thus, their generalisability is limited. This is particularly of concern as there has been greater attention to reading development for children in low-income and middle-income countries in the past decade (Kim, Boyle, Zuilkowski, & Nakamura, 2016; Kim, Lee, & Zuilkowski, in press). For instance, because recent evidence has shown very poor reading achievement outcomes for children in developing countries even after several years of instruction (Gove & Cvelich, 2011), significant resources have been expended on improving reading outcomes in such countries. These interventions have included increased availability of learning assessments, expanded reading interventions and associated intervention strategies (e.g., teacher capacity development, reading materials development and instructional coaching; see Kim et al., 2016, in press, for a review). In the present study, our goal was to contribute to our growing understanding of reading development in languages with transparent orthographies, particularly from developing-country contexts where children first acquire literacy skills in their second language (L2) or in more than one language. Specifically, we investigated the component skills of reading and their structural relations based on theory and prior evidence, using a data set from three sub-Saharan African languages with transparent orthographies.

According to one prominent theoretical model, reading comprehension requires, at a minimum, the ability to decode printed words (word reading proficiency) as well as to comprehend oral language (linguistic comprehension) (called the 'simple view of reading'; Gough & Tunmer, 1986; Hoover & Gough, 1990). This view does not deny that reading comprehension is a complex phenomenon but instead argues that reading comprehension can be defined essentially as processes subsumed under these two abilities: decoding and language comprehension. A large body of evidence has provided empirical support for this theoretical view in first language (L1) and L2 literacy acquisition (Adlof et al., 2006; Catts et al., 2006; Foorman et al., 2015; Joshi et al., 2012; Kendeou et al., 2013; Kendeou et al., 2009; Kim, 2011, 2015a, 2017; Mancilla-Martinez et al., 2011; Verhoeven & van Leeuwe, 2012; see Florit & Cain, 2011 for a review). Although linguistic comprehension has been operationalised in various ways in previous studies (e.g., vocabulary, grammatical knowledge and listening

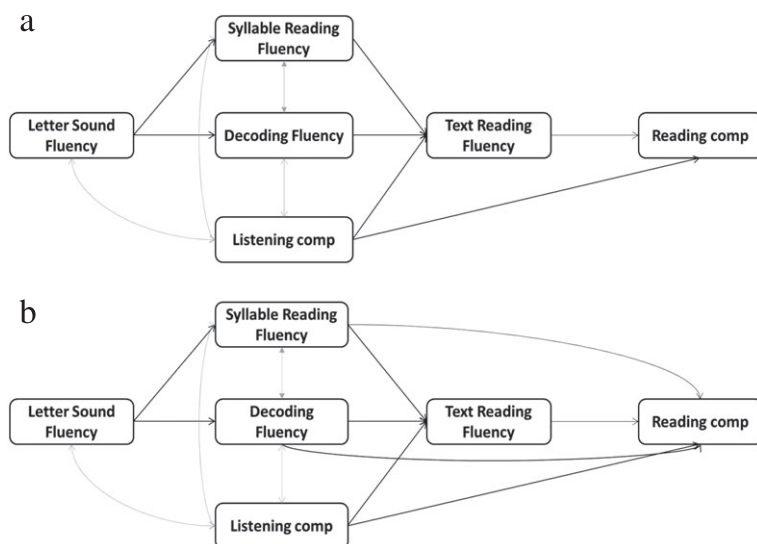
comprehension), listening comprehension captures the simple view of reading because like reading comprehension, it is a discourse-level language comprehension skill that draws on lower-level oral language skills such as vocabulary and grammatical knowledge, as well as other cognitive skills such as working memory, inference and comprehension monitoring (Barnes et al., 1996; Daneman & Merikle, 1996; Florit et al., 2014; Kendeou et al., 2008; Kim, 2015a, 2016, 2017; Kim & Phillips, 2014; Lepola et al., 2012).

Another eminent line of work has shown that (text or oral) reading fluency – the ability to read connected texts with accuracy, speed and expression – is likewise critical to reading comprehension (Fuchs et al., 2001; Jenkins et al., 2003; Kim, 2015b; Kim, Park, & Wagner, 2014; Kim, Petscher, & Foorman, 2015; Kim, Petscher, Schatschneider, & Foorman, 2010; Kim, Wagner, & Lopez, 2012; Kuhn et al., 2010; Kuhn & Stahl, 2003; National Institute of Child Health and Human Development [NICHD], 2000; Roehrig et al., 2008), including in sub-Saharan Africa (Piper, Schroeder, & Trudell, 2015). Theoretically, text reading fluency is related to reading comprehension, because fluent reading affords readers the cognitive funds – such as working memory and attention – to be used for essential comprehension processes (Kim, 2015b; Kim & Wagner, 2015; LaBerge & Samuels, 1974; Samuels, 2006).

Furthermore, text reading fluency is distinguished from lexical-level reading ability (i.e., word reading proficiency) because text reading fluency requires and captures semantic processes beyond those involved in word reading (post-lexical semantic processes; Kim & Wagner, 2015; Jenkins et al., 2003). Recent studies have investigated this speculation by examining whether word reading proficiency together with language comprehension (i.e., listening comprehension) contributes to text reading fluency. As noted earlier, listening comprehension involves semantic processes at the discourse or text level and, thus, captures post-lexical processes that are hypothesised to be a feature that distinguishes text reading fluency from word reading proficiency. Results revealed that text reading fluency indeed was predicted by one's listening comprehension skill as well as word reading fluency (Kim, 2015b; Kim & Wagner, 2015; Kim, Wagner, & Foster, 2011; Kim et al., 2012, 2014; also see Jenkins et al., 2003). However, because of a bottleneck phenomenon, this relationship occurred only when children's word reading reached a certain level of proficiency – that is, word reading constrained the extent to which children could utilise post-lexical semantic processes during reading (Kim & Wagner, 2015). Therefore, text reading fluency acted as a mediator connecting word reading fluency and listening comprehension to reading comprehension (Figure 1), but the mediating role depended on the children's developmental phase of reading, such that at the beginning phase, text reading fluency only partially mediated the relation, whereas at a more advanced level, it completely mediated the relation of word reading proficiency to reading comprehension (Kim, 2015b; Kim & Wagner, 2015; Kim et al., 2012, 2015).

### Present study

In the present study, we expand these previous studies in two important ways. First, we examine theoretically motivated structural relations using data from three sub-Saharan African languages with highly transparent orthographies. As noted earlier, our understanding of reading development is primarily based on English, a language with an opaque orthography. While evidence from transparent orthographies is expanding rapidly (e.g., Kim, 2011, 2015a,b, 2016; Kendeou et al., 2013; Lepola et al., 2016; Torppa et al., 2012), this prior research has been primarily from developed countries. However, reading instruction in developing countries has received increased attention from



**Figure 1.** Two alternative models (complete and partial mediation models), incorporating letter sound fluency, syllable reading fluency, decoding fluency, text reading fluency, listening comprehension and reading comprehension. a. Complete mediation model. b. Partial mediation model.

governments, education donors and nongovernmental organisations in the past decade (Gove & Cvelich, 2011; Kim et al., 2016, in press), with a primary focus on designing and evaluating instructional interventions (Kim et al., 2016). Although this increased intervention focus is crucial, and is not surprising given the astoundingly low literacy achievements in this context (Piper, Zuilkowski, & Ong'ele, 2016; Gove & Cvelich, 2011), it is also critical to systematically investigate whether theories and findings in developed-country contexts can be validated and generalised to contexts with lean resources. This is essential to inform the reading interventions that are implemented in developing countries and to ensure that they are designed to effectively support literacy development in the particular languages of those countries.

We examined the following sublexical, lexical and text reading skills for their structural relations to reading comprehension, based on theory and prior empirical evidence: letter sound knowledge, syllable reading fluency, decoding fluency, text reading fluency and listening comprehension. Letter sound knowledge is one of the most important and strongest predictors of word reading in languages with alphabetic writing systems (see the triangle model in Adams, 1990; see also Ehri, 1998; NICHD, 2000; National Early Literacy Panel, 2008; Snow et al., 1998). Word reading in languages with alphabetic writing systems is founded upon the alphabetic principle – orthographic symbols represent sounds – such that knowledge of letter–sound correspondence is essential. We included decoding skill as it is one of the foundational skills for reading comprehension (see ‘simple view of reading’ above). We examined syllable reading fluency because in these three sub-Saharan languages, syllables are highly salient. Thus, capturing students’ ability to read single syllables is important both to reflect linguistic features in these languages and for psychometric reasons (word reading involving multi-syllabic words may be too difficult for beginning readers).

Based on theory and the empirical evidence described earlier, the chain of relations was hypothesised as follows: letter sound knowledge predicts word reading skills (as measured by syllable reading fluency and decoding fluency), which predicts text reading fluency,

which, in turn, predicts reading comprehension. Listening comprehension would also predict text reading fluency and reading comprehension. Based on this hypothesised chain of relations, we explored two alternative models. The first (Figure 1a) was a *complete* mediation model, in which text reading fluency fully mediated the relation of word reading proficiency to reading comprehension. The second (Figure 1b) was a *partial* mediation model, where text reading fluency partially mediated the relations, such that syllable reading fluency and decoding fluency had direct relations to reading comprehension as well as indirect relations via text reading fluency.

The second way in which our study expands on previous research is by explicitly capturing indirect effects of component skills on reading comprehension. Most previous studies have focused on the direct effects of target component skills on outcomes employing multiple regression (i.e., whether a focal skill in a multiple-regression model is statistically significantly related to an outcome). The lack of statistical significance of a target skill in a multiple-regression model, however, does not necessarily imply lack of an effect on the outcome. If the focal skill is related to the outcome via other variables in the model, its effect, albeit nonsignificant in a multiple-regression model, might be indirect or be mediated by other variables in the statistical model. Therefore, examining only direct effects does not accurately capture total contributions of component skills. As an example, letter sound knowledge is a critical skill for word reading. However, letter sound knowledge is not likely to be significantly related to reading comprehension once word reading is accounted for. Although letter sound knowledge would not have a direct relation to reading comprehension when examined jointly with high-order reading skills such as word reading and text reading, its indirect effect can be estimated via word reading and text reading fluency (Figure 1).

### **Study context: characteristics of Kenya's literacy instruction environment**

Data for the present study are from beginning readers in Kenya. Kenya's language context is similar to that of other sub-Saharan African countries in its diversity, as Kenyans speak about 60 languages (Simons & Fennig, 2018). At the same time, Kenya is somewhat different from other countries because of the unique place of Kiswahili as a moderating language that is not a first language for most Kenyans but does serve as the language of broad communication for a large number of Kenyans. Kenya has two official languages: Kiswahili and English (Republic of Kenya, 2010). Its language policy encourages the use of the language of the local area as the language of instruction for Grades 1–3 (Republic of Kenya, 1976). This language policy, however, faces significant resistance from the community (Bunyi, 2008), which results in limited usage of local language as a language of instruction in practice (Trudell & Piper, 2013), even in contexts with language homogeneity (Piper & Miksic, 2011). In school settings, Kiswahili is used somewhat more frequently than local languages, given that it is taught as a subject. Amongst the approximately 60 languages used by Kenyans, we present results from Kiswahili, which is also relatively widely spoken outside of school in Kenya, and Kikamba and Lubukusu, two first languages spoken primarily in a specific set of counties in Kenya. These languages were chosen because they are relatively homogenous in the two counties from which the data were collected, with Kikamba widely spoken in Machakos County and Lubukusu in the portions of Bungoma County selected. All three languages use the Latin alphabet, as in English, and all three are considered highly transparent orthographically.

Kikamba is spoken by approximately 4.5 million people, 3.9 million of whom would be considered L1 speakers. It is spoken in Machakos, Kitui and Makueni counties, with some L1 speakers in Taita Taveta and Kajiado counties as well. It is a Niger–Congo language and is closely related to the Gikuyu language spoken by the Kikuyu people (Simons & Fennig, 2018). Kikamba has seven vowels and, similar to Gikuyu, uses diacritics to mark vowels. Previous research shows that in the school settings, Kikamba was used very sparingly in Grades 1 to 3 in the areas where it would be expected as a language of instruction, and almost no books or other texts were available in Kikamba (Piper & Miksic, 2011).

Lubukusu is a language with 1.4 million speakers, according to the 2009 census. It is also a Niger–Congo language predominantly spoken in Bungoma, Kakamega and Trans Nzoia counties. It is considered a dialect of the Luhya family of languages (Simons & Fennig, 2018). Lubukusu has only five vowels, is tonal to identify tenses and does not mark vowel length (Schroeder, 2010). Similar to Kikamba, Lubukusu is seldom used instructionally in Grades 1 to 3, and the language is largely limited to particular classes, with very little utilisation of Lubukusu in teaching subjects such as mathematics (Piper & Miksic, 2011).

Kiswahili evolved from languages that intermingled on the Swahili coast in East Africa. It is different in Kenya and in Tanzania, where Kiswahili has a fundamental role in the cultural environment. Kenya's language policy makes Kiswahili the language of instruction in urban and peri-urban areas as well as locations that speak Kiswahili as a first language, mainly near the coast (Republic of Kenya, 1976). Kiswahili is a Bantu language and has connections with Arabic and other languages in the coastal region. Kiswahili is an important part of the instructional language in schools for Grades 1 to 3, with the language being one of the subjects taught daily in classrooms in the research locations (Piper & Miksic, 2011). Schools typically had a modest number of Kiswahili books available, and many classroom aids were written in Kiswahili, though fewer than were written in English.

As indicated, Bungoma and Machakos counties in Kenya were the locations of the study from which we obtained our data. In both counties, Kiswahili is used instructionally, as all children in Kenya are taught a Kiswahili class; and the mother tongue or local area language was being used to instruct the children in this experimental study, which focused on the utilisation of mother tongue in rural areas. Each child was assessed in Kiswahili. In addition, children in Machakos underwent a second assessment in Kikamba, while those in Bungoma were assessed in Lubukusu, as those were the local languages applicable for those two geographic contexts. Consistent with results in other Kenyan and sub-Saharan contexts, the overall reading outcomes in both mother tongues and Kiswahili were low (Kim et al., 2016; Piper, 2010).

While there is no other available research that compares the characteristics of these three languages, we could easily recognise some interesting differences. First, Kikamba is the only language of the three that has diacritics, and Lubukusu is the only language that marks tone. Kiswahili is spoken by a larger number of speakers, and both Kiswahili and Lubukusu are spoken in other East African countries, while Kikamba is spoken primarily in Kenya.

Previous research showed only limited use of the local languages of the catchment area (including Lubukusu and Kikamba, analysed here) as languages of instruction in Grades 1 to 3, even though the language policy dictates their use as the primary language used to teach the subject areas, such as mathematics (Piper & Miksic, 2011). Kiswahili was more likely to be used, though its use in rural areas was largely limited to the daily Kiswahili subject (Trudell & Piper, 2013). In peri-urban contexts, where the language of the



catchment area was Kiswahili, Kiswahili was sometimes used as the language of instruction in the subject areas, though less than the policy demands. In many schools, the de facto language of instruction was English, with Kiswahili primarily being used in the daily Kiswahili class. In policy, children would learn literacy skills in all three languages, but prior to interventions like the Primary Math and Reading (PRIMR) Rural Expansion (see Method section), the instructional methods focused more on teaching content rather than teaching children how to read and comprehend in these languages (Piper & Miksic, 2011).

This analysis focuses on the rural areas that dominate Kenya, where mother tongue (such as Kikamba or Lubukusu) would be expected to be the L1 and the language of instruction, but Kiswahili and English were in fact typically more frequently used. Eligibility for the randomised controlled trial of the impact of mother tongue instruction on learning outcomes was a criterion for inclusion in the study. Taking the country as a whole, the de facto language of instruction was English (Piper & Miksic, 2011), though early literacy assessment results showed that the emphasis on English in actual classrooms was an inefficient pathway towards improved reading outcomes (Piper, Zuilkowski, & Ong'ele, 2016).

## Method

### *Participants and sites*

The data set that we employed in our study came from the PRIMR Rural Expansion intervention (2013–2014), funded by the UK Department for International Development. The focus of the PRIMR research was the impact of a mother tongue (L1) literacy programme implemented in comparison with a non-mother-tongue literacy programme (see Piper, Zuilkowski, & Ong'ele, 2016, for details). We used data from the children in the control group at the October 2014 endline of the PRIMR intervention, when children were in Grade 2. All children were assessed in Kiswahili as well as their mother tongue appropriate for that county. Sample sizes in the three languages were as follows: Kiswahili ( $N = 946^1$ ), Kikamba ( $N = 444$ ) and Lubukusu ( $N = 499$ ). Across the samples, approximately half the children were girls and half boys. With respect to the language characteristics of the sampled population, 90% of the students in Machakos county spoke Kikamba at home, and 73% of the students in Bungoma spoke Lubukusu at home (Piper, Zuilkowski, Kwayumba, & Oyanga, 2018).

Data from Grade 2 were used as there were substantial floor effects in reading skills in Grade 1, which is not unusual in developing countries (Piper, 2010; Kim et al., 2016). Data from the control group were used to capture the nature of relations in typical or business-as-usual conditions. In the control group, reading instruction generally did not include explicit or systematic instruction on letter–sound correspondences (Dubeck et al., 2012). Instead, teachers used mostly whole-class instruction, or the whole-word ‘look and say’ method, whereby teachers would point to a word, say the word aloud, and ask the children to repeat the word. For reading comprehension, teachers primarily relied on asking factual recall questions after the passages were read (Kim et al., 2016). The official language of instruction was the language of the local area, and by policy, children would have been taught literacy in the assigned L1 and also taught Kiswahili and English (Kenya Institute of Education, 1992). The language of instruction would have been Lubukusu in rural Bungoma, Kikamba in rural Machakos and Kiswahili in peri-urban locations.

Our recent work in Kenya using data from the same study examined mathematics classroom language use as a proxy for other non-language subjects. We found that local language (either Kikamba or Lubukusu, depending on the location) was used in 15% of mathematics instructional time during the endline data collection period in October 2014. Kiswahili was used 21% of the time. While this means that English was used during nearly two thirds of mathematics instructional time, this rate actually was indicative of slightly more local language and Kiswahili language use in these classrooms than in the other treatment groups (Piper, Zuilkowski, Kwayumba et al., 2018).

### *Measures*

Children's letter sound fluency, syllable reading fluency, decoding fluency, text reading fluency and reading comprehension were assessed by widely used measures, called the Early Grade Reading Assessment (EGRA; Gove & Wetterberg, 2011). EGRA tools were originally adapted from those available in the United States (e.g., Dynamic Measurement Group, 2008) and have been used in more than 100 languages in developing countries (Dubeck et al., 2016; Gove & Cvelich, 2011; Kim et al., 2016). The Kenyan EGRA had 0.96 and 0.98 concurrent validity values with the Uwezo assessments (Uwezo, 2016). In India, similar correlational results were found between an EGRA and the Annual Status of Education Report, with correlations between 0.90 and 0.94 (Vagh, 2012).

The items within the measures for the three languages were developed by literacy and language experts in Kenya to adequately reflect features of each language. Efforts were made to ensure that task difficulty was similar across the three languages, but their equivalence was not the primary goal of this study; our primary research question was not about the mean level of reading skills across the three languages but about the covariance structure of skills across the languages.

*Letter sound fluency.* Letter sound fluency was a timed task designed to measure children's letter sound knowledge. The assessment was undertaken in a one-on-one setting between an assessor and a student. In the letter sound fluency task, the student read from a laminated array of 100 letters, which were presented in a random pattern in a mixture of upper and lower case. The letters were in different orders in the three languages, with each letter in each language assigned according to the frequency of that letter in the existing literacy materials available in those languages. The score was the number of letter sounds correctly identified per minute. There was a discontinuation rule in place for children who struggled with reading all of the first 10 letters. The reliability estimates for the tools in Kenya were 0.92 in Kiswahili, 0.88 in Kikamba and 0.86 in Lubukusu.

*Syllable reading fluency.* Student syllable reading fluency was measured using a task similar to the letter sound fluency task described earlier. The syllable fluency task presented the 100 most frequently occurring syllables in each language on a laminated sheet in random order. The frequency was determined based on an analysis of the reading materials that existed in those languages. Children's fluency tasks were measured as the number of syllables correctly read per minute. Administration was discontinued when the child could not read the first five syllables correctly. Cronbach's alpha reliability statistics were 0.90 in Kiswahili, 0.86 in Kikamba and 0.84 in Lubukusu.



*Decoding fluency.* Student decoding skills were assessed using a nonsense word or pseudoword fluency task. The laminated sheet presented to the children had an array of 50 non-words, and the scores were derived from the number of nonsense words correctly read in a minute. Administration was discontinued when the child could not read the first five nonsense words correctly. Reliability estimates for this task were 0.90 in Kiswahili, 0.86 in Kikamba and 0.84 in Lubukusu.

*Text/oral reading fluency.* To measure oral text reading fluency, each student was asked to read a narrative story of approximately 60 words aloud. Each story was developed by language experts with specific expertise in early literacy in that language, and the stories developed were appropriate for children in Grade 2. Oral reading fluency rates were determined by measuring the number of words correctly read per minute. Administration was discontinued when the child could not read the words on the first line of text. Reliability estimates were 0.90 in Kiswahili, 0.86 in Kikamba and 0.84 in Lubukusu.

*Reading comprehension.* Reading comprehension was assessed using a set of five comprehension questions that were asked after the children had read the connected text passage described earlier. After finishing the passage, the stimuli were removed. Children answered questions that correlated with the portion of the story each child read within 1 minute. If the student was unable to correctly read any words, no reading comprehension questions were asked, and the student's reading comprehension score was zero. Reliability estimates for the reading comprehension measures were 0.91 in Kiswahili, 0.88 in Kikamba and 0.85 in Lubukusu. Note that, using linear equating methods, some of the scores were over 1 for comparison with other assessment rounds (Albano & Rodriguez, 2012).

*Listening comprehension.* Listening comprehension was assessed using a tool similar to the reading comprehension measure. Instead of the student reading the passage aloud, the story in this task was read aloud by the assessor, and five comprehension questions were asked of the student immediately after the story was read. The Kiswahili passage was 40 words long, the Kikamba passage was 52 words long and the Lubukusu passage was 70 words long, though passage length across languages is difficult to compare. Reliability estimates were 0.95 in Kiswahili, 0.93 in Kikamba and 0.93 in Lubukusu.

### *Procedures*

*Assessment procedures.* The assessors involved in this study had experience with prior EGRA studies over several years. The team had been implementing early literacy assessments since 2009. The selected assessors were given 5 days of initial training in Nairobi. During this training, each assessor underwent three rounds of inter-rater reliability testing. Assessors who performed poorly on the reliability testing were removed prior to actual data collection. A pilot assessment was implemented at field sites during the initial training. During full data collection – done with electronic tablets – a field supervisor controlled the quality of both the data and each assessor's work. In addition, an overall field-based data quality manager checked the results each evening and gave specific assessors feedback on missing or poor-quality data on a daily basis (see RTI International, 2016, for procedures). The average inter-rater reliability score was 0.97.

### *Data analysis*

The primary analytic strategy was path analysis (Figure 1). Model fits were evaluated using multiple indices such as chi-square statistics, Akaike information criterion, Bayesian information criterion, comparative fit index (CFI), the Tucker–Lewis index (TLI), root mean square error of approximation and standardised root mean square residuals. Root mean square error of approximation values below 0.08, CFI and TLI values equal to or greater than 0.95 and standardised root mean square residuals equal to or less than 0.05 indicate an excellent model fit. TLI and CFI values greater than 0.90 are considered to be acceptable (Kline, 2005). Comparisons of model fits between the complete and partial mediation models were made by chi-square test because these models were nested.

## **Results**

### *Descriptive statistics*

Table 1 presents descriptive statistics in each language. A couple of things are worth noting. First, there were large variations amongst children in the skills within and across languages. For instance, on average, children were able to name approximately 14 sounds of letters per minute ( $SD = 17.10$ ) in Kiswahili, whereas means were higher in Kikamba ( $M = 17.27$ ;  $SD = 17.38$ ) and lower in Lubukusu ( $M = 9.72$ ;  $SD = 12.88$ ). In text reading fluency, children's mean performance was higher in Kiswahili ( $M = 10.58$ ;  $SD = 15.74$ ) than in Kikamba ( $M = 7.86$ ;  $SD = 11.67$ ) or Lubukusu ( $M = 3.66$ ;  $SD = 7.43$ ). In fact, it is notable that mean performances in reading tasks in Lubukusu were substantially lower than those for the Kiswahili and Kikamba samples across measures, with effect sizes (Cohen's  $d$ ) ranging from 0.25 (reading comprehension between Kikamba and Lubukusu) to 0.60 (text reading fluency between Kiswahili and Lubukusu). In contrast, mean performances in listening comprehension were stronger in Kikamba (0.42) and Lubukusu (0.32) compared with Kiswahili. Note, however, that test scores cannot be directly compared across languages, as the tests themselves were not completely equivalent because of language differences. Second, there were varying degrees of floor effects in the literacy tasks. For instance, in the letter name fluency task in Kiswahili, 40% of the children scored 0 while the rest of the scores were spread evenly from 1 to 96. Similarly, approximately 39% of the children scored 0 in the syllable reading task while the rest ranged from 1 to 99. In the decoding fluency and text reading fluency tasks, approximately 56% and 54% scored 0. Floor effects were most severe in reading comprehension, such that 75%, 76% and 87% of the Kiswahili, Kikamba and Lubukusu samples, respectively, scored zero. Overall, these results indicate the unfortunate reality of low achievement in literacy skills for many children in developing countries even after years of reading instruction (Kim et al., 2016). For statistical modelling, these floor effects are not ideal because they reduce variance and are an important weakness of this study. However, it should be noted that a floor effect is not dichotomous but instead is on a continuum. In the present study, despite floor effects, there were large variations in the tasks, and the overall distribution as measured by skewness ( $\leq 3$ ) and kurtosis ( $\leq 7$ ) was acceptable. Furthermore, it is important to retain those who scored zero because they reflect the literacy achievement status of participating children and these contributed to the variation of scores. Because data transformations did not make notable differences in distributional properties, subsequent analyses reported here are based on raw scores.

**Table 1.** Descriptive statistics.

Task	Kiswahili for complete sample ( <i>N</i> = 946)					Kikamba ( <i>N</i> = 444)					Lubukusu ( <i>N</i> = 499)				
	<i>M</i>	<i>SD</i>	Min– Max	Skew	Kurtosis	<i>M</i>	<i>SD</i>	Min– Max	Skew	Kurtosis	<i>M</i>	<i>SD</i>	Min– Max	Skew	Kurtosis
Letter sound fluency	14.11	17.10	0–96	1.30	1.19	17.27	17.38	0–80	1.23	1.21	9.72	12.88	0–65	1.44	1.73
Syllable reading fluency	19.22	22.42	0–99	1.00	0.04	18.45	19.65	0–91	0.95	0.04	11.28	15.66	0–86	1.55	2.23
Decoding fluency	8.45	12.32	0–50	1.35	0.08	5.91	8.26	0–39	1.33	1.03	4.26	8.10	0–39	1.95	2.92
Text reading fluency	10.58	15.74	0–60	1.42	1.01	7.86	11.67	0–58	1.62	2.30	3.66	7.43	0–40	2.22	4.61
Reading comprehension	0.52	1.06	0–5	2.14	3.84	0.37	0.77	0–4	2.24	4.83	0.20	0.59	0–3	3.12	9.40
Listening comprehension	1.62	1.39	0–5	0.44	–0.92	2.20	1.39	0–5	–0.14	–0.77	2.13	1.77	0–5	0.05	–1.43

*Note:* *M* = mean; *SD* = standard deviation.

Table 2 displays correlations between measures across the three samples. All the tasks were positively related to each other in the expected directions, and patterns were overall similar across the three languages. Letter sound fluency was moderately to strongly related to reading skills ( $0.42 \leq rs \leq 0.75$ ). Syllable reading fluency ( $0.64 \leq rs \leq 0.91$ ) and decoding fluency ( $0.66 \leq rs \leq 0.92$ ) were also strongly related to other reading skills across the three languages. Listening comprehension was moderately related to reading measures in Kiswahili and Kikamba ( $0.37 \leq rs \leq 0.41$ ), whereas its relation in Lubukusu was weak ( $0.10 \leq rs \leq 0.32$ ).

### *Structural relations*

The models shown in Figure 1 were fitted to the data in the three languages simultaneously; model fit statistics are presented in Table 3. In Kiswahili, chi-square tests indicated that the partial mediation model was superior to the complete mediation model ( $\Delta\chi^2 = 24.98$ ,  $p < .001$ ). In contrast, in Kikamba and Lubukusu, model fit was not different ( $\Delta\chi^2 = 2.70$ ,  $p = .26$  in Kikamba;  $\Delta\chi^2 = 0.99$ ,  $p = .61$  in Lubukusu), and therefore, we chose the more parsimonious, complete mediation model as the final model.

Standardised path coefficients for the final models in the three languages are shown in Figure 2. We found several similarities across the languages. Letter sound fluency was strongly related to syllable reading fluency ( $0.72 \leq \beta_s \leq 0.75$ ,  $p < .001$ ) and decoding fluency ( $0.62 \leq \beta_s \leq 0.68$ ,  $p < .001$ ). Syllable reading fluency was weakly related to text reading fluency ( $0.11 \leq \gamma_s \leq 0.21$ ,  $p \leq .001$ ) after accounting for decoding fluency and listening comprehension. Decoding fluency, on the other hand, was strongly related to text reading fluency ( $0.67 \leq \gamma_s \leq 0.81$ ,  $p < .001$ ). Listening comprehension was very weakly, although statistically significantly, related to text reading fluency, after accounting for syllable reading fluency and decoding fluency ( $0.04 \leq \gamma_s \leq 0.08$ ,  $p < .001$ ). Text reading fluency was consistently strongly related to reading comprehension across the three languages ( $0.73 \leq \gamma_s \leq 0.77$ ,  $p < .001$ ). When it comes to the relation of listening comprehension to reading comprehension, the magnitude was weak ( $\beta_s = 0.19$  and  $0.18$ ,  $ps < .001$  in Kiswahili and Lubukusu, respectively) but particularly so in Kikamba ( $\beta = 0.03$ ,  $p = .32$ ).

Direct relations of syllable reading fluency and decoding fluency to reading comprehension over and above text reading fluency varied across the three languages. In Kikamba and Lubukusu, they were not directly related to reading comprehension after accounting for the other variables in the model (complete mediation model). In Kiswahili, the partial mediation model was supported, such that decoding fluency was directly and positively related to reading comprehension ( $\beta = 0.22$ ,  $p < .001$ ), whereas syllable reading fluency had a suppression effect ( $\beta_s = -0.20$ ,  $p < .001$ ). The total variance explained in the endogenous variables was as follows: 73% in reading comprehension, 85% in text reading fluency, 42% in decoding fluency and 53% in syllable reading fluency in Kiswahili; 61% in reading comprehension, 80% in text reading fluency, 39% in decoding fluency and 56% in syllable reading fluency in Kikamba; and 62% in reading comprehension, 78% in text reading fluency, 46% in decoding fluency and 53% in syllable reading fluency in Lubukusu.

Total effects (standardised regression weights) of component skills on reading comprehension across the three languages are displayed in Table 4. Across the three languages, the largest effects were found for text reading fluency ( $0.73$ – $0.77$ ), followed by decoding fluency ( $0.49$ – $0.82$ ) and letter sound fluency ( $0.44$ – $0.45$ ). Syllable reading fluency had varied total effects, ranging from  $-0.12$  in Kiswahili due to the suppression effect to  $0.16$  in Lubukusu. Listening comprehension had relatively small effects, ranging from  $0.08$  to  $0.23$ .

**Table 2.** Bivariate correlations between tasks.

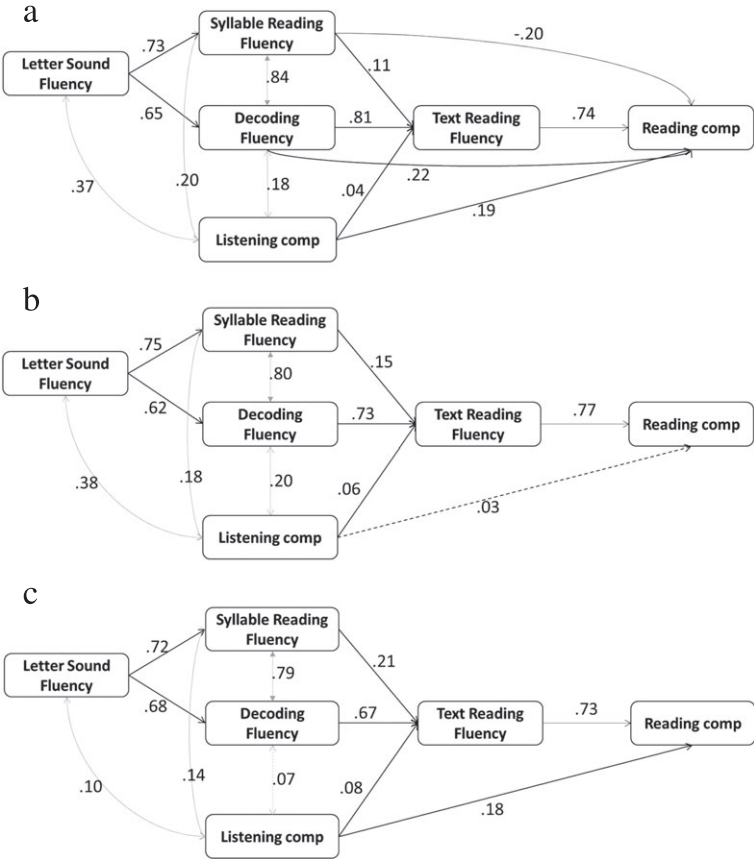
Variables	Kiswahili					Kikamba					Lubukusu				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
1. Letter sound fluency	—					—					—				
2. Syllable reading fluency	0.73	—				0.75	—				0.73	—			
3. Decoding fluency	0.65	0.91	—			0.62	0.88	—			0.68	0.89	—		
4. Text reading fluency	0.59	0.86	0.92	—		0.60	0.82	0.89	—		0.59	0.82	0.87	—	
5. Reading comprehension	0.45	0.71	0.79	0.84	—	0.42	0.64	0.71	0.78	—	0.43	0.64	0.66	0.77	—
6. Listening comprehension	0.37	0.41	0.38	0.38	0.47	0.38	0.41	0.39	0.41	0.35	0.10	0.17	0.12	0.20	0.32

**Table 3.** Model fit statistics for complete and partial mediation models in Kiswahili, Kikamba and Lubukusu samples.

Model	$\chi^2$ (df)	p-value	CFI	TLI	AIC	BIC	RMSEA	SRMR	$\Delta\chi^2$ ( $\Delta df$ ), p-value
<b>Kiswahili</b>									
Complete mediation	51.48 (4)	<.001	0.99	0.97	32,522.03	32,633.63	0.11	0.018	
Partial mediation	26.50 (2)	<.001	1.00	0.97	32,501.05	32,622.35	0.11	0.014	24.98 (2), <.001
<b>Kikamba</b>									
Complete mediation	7.77 (4)	.10	1.00	0.99	14,631.38	14,725.59	0.046	0.009	
Partial mediation	5.07 (2)	.08	1.00	0.99	14,632.69	14,735.08	0.059	0.007	2.70 (2), .26
<b>Lubukusu</b>									
Complete mediation	6.02 (4)	.20	1.00	1.00	15,557.90	15,654.79	0.032	0.009	
Partial mediation	5.03 (2)	.08	1.00	0.99	15,560.91	15,666.23	0.055	0.01	0.99 (2), .61

*Note:* CFI, comparative fit index; TLI, Tucker–Lewis index; AIC, Akaike information criterion; BIC, Bayesian information criterion; RMSEA, root mean square error of approximation; SRMR, standardised root mean square residuals.





**Figure 2.** Standardised path coefficients in Kiswahili, Kikamba and Lubukusu. *Note:* Double-headed arrows represent covariances. Solid lines represent statistically significant relations at 0.05 level, whereas dashed lines represent nonsignificant relations. Comp, comprehension. a. Kiswahili. b. Kikamba. c. Lubukusu.

Discussion

In this study, we examined the component skills of reading comprehension and their structural relations informed by theories and empirical evidence, using data from three sub-Saharan African languages with transparent orthographies in Kenya. Although the nature of the relations of syllable reading fluency and decoding fluency to reading comprehension differed amongst the three languages, the overall results showed that the hypothesised relations fitted data very well in the three languages and explained large amounts of total variance in reading outcomes, such as text reading fluency and reading comprehension.

First, letter sound knowledge, as hypothesised, was fairly strongly to strongly related to word reading skills (as measured by syllable reading fluency and decoding fluency) across the three languages and treatment statuses ( $0.62 \leq \beta_s \leq 0.75$ ). These results indicate the foundational role of letter sound knowledge in word reading skills, convergent with previous studies (see NICHD, 2000, for a review). Its role in reading was further confirmed in its substantial *indirect* effect in reading comprehension (0.43–0.46) via syllable reading fluency, decoding reading fluency and text reading fluency.

**Table 4.** Direct, indirect and total effects of letter sound fluency, syllable reading fluency, decoding fluency, text reading fluency and listening comprehension on reading comprehension in Kiswahili, Kikamba and Lubukusu.

Variables	Kiswahili			Kikamba			Lubukusu		
	Direct	Indirect	Total	Direct	Indirect	Total	Direct	Indirect	Total
Letter sound fluency	—	0.44	0.44	—	0.44	0.44	—	0.45	0.45
Syllable reading fluency	−0.20	0.8	−0.12	—	0.12	0.12	—	0.16	0.16
Decoding fluency	0.22	0.60	0.82	—	0.56	0.56	—	0.49	0.49
Text reading fluency	0.74	—	0.74	0.77	—	0.77	0.73	—	0.73
Listening comprehension	0.19	0.03	0.22	0.03	0.05	0.08	0.18	0.06	0.23*

\*Due to rounding.

Syllable reading fluency and decoding fluency were also related to text reading fluency. The strong relation of decoding fluency ( $0.67 \leq \gamma_s \leq 0.81$ ) to text reading fluency is in line with theory and prior empirical evidence (e.g., Jenkins & Jewell, 1993; Kim et al., 2010, 2011, 2014; NICHHD, 2000; Roehrig et al., 2008). Syllable reading fluency, although weak in magnitude ( $0.11 \leq \gamma_s \leq 0.21$ ), was consistently related to text reading fluency across the three languages, even after accounting for decoding fluency and listening comprehension. To our knowledge, the role of syllable reading skill in text reading fluency (and reading comprehension) has not been examined in earlier studies and suggests its unique role in languages for which the syllable is a highly salient unit. The role of syllable reading in word reading was previously reported in Korean (Cho, 2009). The Korean language has a simple syllabic structure with four different syllable types (V, VC, CV and CVC). Open syllables are prevalent, and the syllable is a highly salient phonological unit (Kim, 2007, 2011). In contrast, languages such as English have numerous syllable structures, and syllable boundaries are not as clear (Moats, 2010). Studies have shown that in languages where open syllables are prevalent, syllable awareness plays an important role in word reading (e.g., Korean; Cho & McBride-Chang, 2005; Durgunoğlu & Öney, 1999). However, evidence is scarce about the role of syllable reading skill in overall reading development. Future studies are warranted to elucidate the unique role (or variation of roles) of syllable reading in reading development across languages.

Listening comprehension was weakly but consistently related to text reading fluency ( $0.04 \leq \beta_s \leq 0.08$ ) in the three languages after accounting for syllable reading fluency and decoding fluency. The contribution of language comprehension to text reading fluency was expected, given the theoretical account that text reading involves post-lexical semantic processing (Jenkins et al., 2003; Kim, 2015b), and thus, text reading draws not only on word reading skills (NICHHD, 2000) but also on comprehension skills (Jenkins et al., 2003; Kim, 2015b; Kim & Wagner, 2015; Kim et al., 2012). The relation of listening comprehension to text reading fluency is convergent with findings for English (Kim et al., 2012; Kim & Wagner, 2015) as well as Korean (Kim, 2015; Kim et al., 2014). The weak magnitude of relations in our sample is similar to what was learned for beginning readers in

English (i.e., Grade 1; Kim & Wagner, 2015) and Korean (Kim, 2015b; Kim et al., 2014) but different from other research on more advanced readers (0.30 for fourth graders in English; Kim & Wagner, 2015).

However, given that we used cross-sectional data in our present study, it is unclear whether the weak magnitude occurred because of developmental stage (i.e., beginning phase of reading) or differences in the transparency of the writing systems in the Kenyan languages. Theoretically and empirically, the role of listening comprehension in text reading fluency is expected to increase to a certain extent as children's reading skills develop because word reading places less mental constraints as development progresses (Kim, 2015b; Kim & Wagner, 2015). However, whether the contribution of comprehension to text reading fluency is similar in magnitude in transparent and opaque orthographies is unclear. Future cross-linguistic longitudinal studies that track children from the beginning of elementary school into upper elementary grades are needed to tease out the role of comprehension in text reading fluency as a function of orthographic transparency and reading development.

For the reading comprehension outcome, text reading fluency was strongly and consistently related across the languages ( $0.73 \leq \gamma_s \leq 0.77$ ). This strong relation is convergent with many previous studies involving English and other languages (Jenkins et al., 2003; Jenkins & Jewell, 1993; Kim et al., 2010, 2014; Kim & Wagner, 2015; Roehrig et al., 2008), supporting the role of text reading fluency in reading comprehension across languages with varying depths of orthography. It must be noted that text reading fluency has been widely assessed in developing countries in the past decade. However, the component skills of text reading fluency and its relation to reading comprehension have not been systematically examined in the context of developing countries. Convergent with theory and prior work, listening comprehension was also directly related to reading comprehension after accounting for all the other variables in the model, at least in Kiswahili and Lubukusu. That its relation was weak is likely due to the phase of reading development – listening comprehension plays a larger role at a later phase of reading development (Adlof et al., 2006; Florit & Cain, 2011; Kim, 2015b; Kim & Wagner, 2015). Unlike Kiswahili or Lubukusu, in Kikamba, listening comprehension was not independently related to reading comprehension. Given the similar pattern of relations in bivariate correlations in Table 2 and the path models (Figure 2), the cause for this differential relation is unclear.

Although the overall structural relations were similar across the three languages, the nature of the relations of syllable reading fluency and decoding fluency to reading comprehension, over and above text reading fluency and listening comprehension, varied within the different languages. In Kikamba and Lubukusu, text reading fluency completely mediated the relations of syllable reading fluency and decoding fluency to reading comprehension, whereas in Kiswahili, decoding fluency had a direct positive relation, and syllable reading fluency had a suppression effect.

What explains these differences across the languages is not clear. One potential explanation might be very strong relations amongst syllable reading fluency, decoding fluency, text reading fluency and reading comprehension in Kiswahili. As shown in Table 2, their relations in general were strong across the three languages but particularly in Kiswahili. These strong relations might be responsible for the suppression effect of the syllable reading fluency on reading comprehension – positive in bivariate correlation but negative in a multivariate model. Another potential factor could be the fact that Kiswahili typically was a second language for the children in the sample, and therefore, the relationship between the component skills might have been different whether the language was the first or second

language for the children. Not surprisingly, children's listening comprehension was slightly better in Lubukusu or Kikamba than in Kiswahili, but reading skills were better in Kiswahili than in either Lubukusu or Kikamba because reading in Kiswahili was consistently taught (Piper et al., 2016). Therefore, the nature of relations amongst word reading fluency (as measured by syllable reading fluency, decoding fluency, text reading fluency and reading comprehension) might differ for L1 versus L2 (Kim, 2012). However, given the lack of empirical evidence, the exact mechanism of this differential relation remains unclear and requires a future investigation.

The present findings highlight the importance of accounting for both direct *and* indirect effects to capture the total effects of the component skills on reading comprehension. As noted earlier, the majority of previous studies focused on the direct and unique effects of target component skills and, thus, were not able to account for indirect effects. Letter sound knowledge is a case in point. Letter sound knowledge, as expected based on theory and prior evidence, was strongly related to syllable reading fluency and decoding fluency, which were, then, related to text reading fluency and reading comprehension. Although not directly related to reading comprehension,<sup>2</sup> its indirect effect was substantial, ranging from 0.44 to 0.45. Furthermore, the total effect of decoding fluency on reading comprehension was also substantial, ranging from 0.49 to 0.82, once its indirect effects were accounted for.

These findings have implications for the growing area of intervention research focused on improving reading outcomes in sub-Saharan Africa (Kim et al., 2016). Using three Kenyan languages in different language families with varied levels of overall reading skills, we found that instruction in letter sound knowledge, syllable knowledge, decoding and oral language is likely necessary. Typical reading instruction in Kenya, like many other countries in sub-Saharan Africa, does not provide explicit and systematic instruction in the relation between graphemes and phonemes (Dubeck et al., 2012). The evidence from our work, together with previous studies (for review, see Kim et al., 2016; Nag et al., 2014; NICHD, 2000), indicates the importance of these skills in improving instruction. Without intervention, many children in sub-Saharan African settings such as Kenya will not learn to read proficiently. On the other hand, interventions that teach these skills have seen dramatically improved literacy outcomes at a large scale in Kenya (Freudenberger & Davis, 2017), Rwanda (Education Development Center, 2017) and Uganda (Brunette, Piper, Jordan, & Nabacwa, 2017).

Although informative, these results should be interpreted with some limitations of our study in mind. In particular, severe floor effects in reading comprehension are an important limitation. Although this reflects the achievement status in these rural Kenyan settings, and the hypothesised relations were supported by the evidence overall, the reduced variance in these skills might have influenced our findings. Correlations shown in Table 2 are all in expected directions and are in line with previous studies. However, the extent to which floor effects, particularly in reading comprehension, impacted the magnitudes of relations is unknown. As noted earlier, an important future direction is longitudinal research to investigate the developmental trajectories of reading and the relations of component skills to reading as children advance their reading skills. Another limitation is related to the measurement of reading comprehension skills. Reading comprehension was measured by a single passage with five questions; questions were asked based on how much of the text each child read, because the children read different amounts of text. Similar to reading comprehension, a single passage with five questions was used in listening comprehension. However, in listening comprehension, children heard the entire story before answering questions. This measurement approach to reading comprehension has been shown to be

valid in prior work in developing countries as it captured individual differences in children's reading comprehension skills and intervention effects (Piper, 2010; Piper, Schroeder, & Trudell, 2015; Piper, Zuilkowski, Dubeck, Jepkemei, & King, 2018). However, because of the differences between reading and listening comprehension in terms of the amount of text presented prior to asking questions, demands on memory and attention by these tasks might have differed. Future work is needed with a greater number of passages for both reading comprehension and listening comprehension, along with an equivalent assessment method. Finally, future studies including oral language skills beyond listening comprehension – such as vocabulary and grammatical knowledge – would be informative to fully capture the oral language skills of children in multilingual contexts and to unpack the component skills that contribute to reading comprehension.

Our findings revealed the importance of the component skills of reading and the nature of structural relations in three sub-Saharan languages with transparent orthographies. The results also uncovered the indirect effects of component skills, providing a more accurate picture of the contributions of various component skills. Finally, the findings suggest the need for interventions to consider phonics skills as an essential part of programme design in sub-Saharan contexts.

### Notes

1. For three children, their data in their L1 were not available, and therefore, the sample size in Kiswahili is slightly greater than the sum of the number of children assessed in Kikamba and Lubukusu ( $N = 943$ ).
2. Post hoc analysis revealed that letter sound fluency did not have a direct relation to reading comprehension after accounting for all other variables in the model.

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